PHILIPS

COUNTER/TIMER 512 MHz/1ns PM 6650

9446 066 50...1

Operating Manual

740215/1/01

9499 460 06011

IMPORTANT

In correspondence concerning this instrument, please quote the type number and the serial number as given on the type plate on the rear of the instrument.

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DIRECTION FOR USE

LIST OF FIGURES

I. INTRODUCTION

The PM 6650 can perform CW frequency, burst frequency, ratio, totalize, single period, period average, time interval and time interval average measurements.
The frequency range is 512 MHz and the accuracy at time interval measurement is 1 ns.
The three models PM 6650 A, B and E are identical except the stability of the clock oscillator used.
Each model features two direct-gated input channels A and C for frequency measurement, and a third input B for time interval or ratio measurement or external gating of channel A. The inputs have selectable 1 MΩ and 50 Ω impedance. The nine-digit planar display has leading zero blanking and switchable memory.
The PM 6650 can be used as bench equipment or in an automatic test system using the options available.
Typical applications are time domain measurements such as frequency, period time, pulse duration, phase difference.
Pulsed carriers can be measured directly using the burst mode.

II. CABINETS AND BLANK PANELS

The PM 6650 is supplied without cabinet. The counter can be placed either in a bench cabinet or in a 19″ cabinet.

PM 9714 A

Bench cabinet (4/6 rack size) including handle, feet, tilting bracket and skin plate covers.

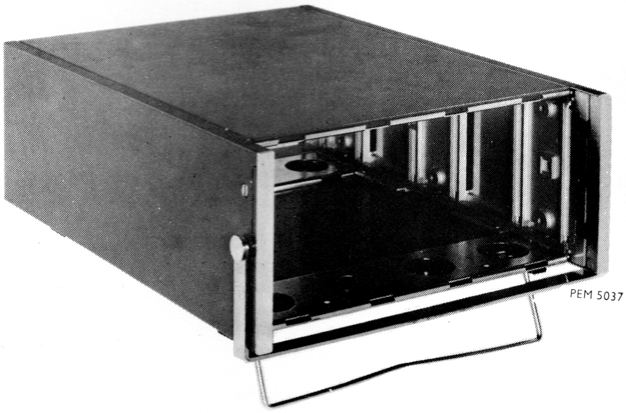

Figure II-1. Bench cabinet, 4/6 rack sizes

PM 9716 A

19″ cabinet (6/6 rack size) including grips, feet, tilting bracket, skin plate covers and cable cover with 2 angular brackets for 19″ rackmounting.

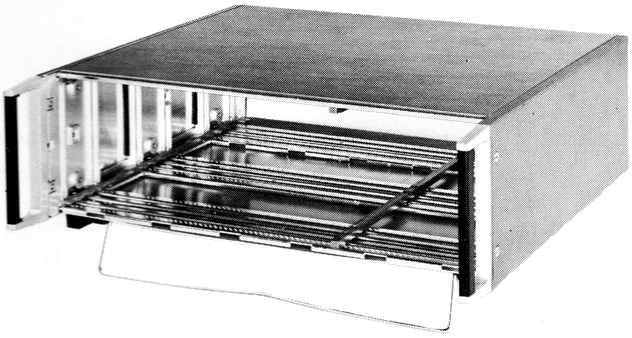

Figure II-2. 19″ cabinet, 6/6 rack size

PM 9721

Blank panel to cover 1/6 empty space.

PM 9722

Blank panel to cover 2/6 empty space when the PM 6650 is placed in PM 9716 A cabinet and no sub-unit is used.

III. TECHNICAL DATA

Properties expressed in numerical values with statement of tolerances are guaranteed. Numerical values without tolerances are intended for information purposes only and indicate the properties of an average instrument. The numerical values hold good for the nominal mains voltage.

A. MEASUREMENTS

Frequency

Range	DC . . . 512 MHz
Mode	normal frequency or burst frequency
Gate times	100 ns . . . 100 s (in decade steps)
Accuracy	±1 count ± time base accuracy
Inputs	channel A (DC . . . 160 MHz) channel C (5 MHz . . . 512 MHz)
Display	kHz, MHz and GHz, decimal point automatically positioned

Period

Range	DC . . . 10 MHz
Frequency counted	100 MHz . . . 1 Hz (in decade steps)
Resolution	10 ns . . . 1 s
Accuracy	±1 count ± time base accuracy ± trigger error *
Input	channel A
Display	µs, ms and s, decimal point automatically positioned

Period Average

Range	DC . . . 10 MHz
Frequency counted	100 MHz
Periods averaged (N)	1 . . . 10^8 (in decade steps)
Resolution	$\frac{10\ \text{ns}}{N}$
Accuracy	±1 count ± time base accuracy ± trigger error */N
Input	channel A
Display	ns or µs, decimal point automatically positioned

Time Interval

Range	40 ns . . . 10^9 s (approx. 31 years)
Frequency counted	100 MHz . . . 1 Hz (in decade steps)
Resolution	10 ns . . . 1 s
Time interval repetition rate	max. 10 MHz
Accuracy	±1 count ± time base accuracy ± trigger error **
Inputs	Channels A and B; can be common or separate
Display	µs, ms and s, decimal point automatically positioned

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* trigger error is $\leq \pm 3 \times 10^{-3}$ for sine wave signals at specified sensitivity with signal to noise ratio of ≥ 40 dB

** trigger error is $\leq \frac{\pm 2.5 \times 10^{-3}}{\text{signal slope (V/ns)}}$ ns

Time Interval Average

Range	100 ps . . . 10 s
Minimum time from stop to start	50 ns
Frequency counted	100 MHz
Time intervals averaged (N)	1 . . . 10^8 (in decade steps)
Time interval repetition rate	max. 10 MHz
Resolution	$\frac{10\ \text{ns}}{\text{N}}$
Accuracy	$\pm 1\ \text{ns} \pm \text{time base accuracy} \pm \frac{10\ \text{ns} \pm \text{trigger error}^{**}}{\sqrt{\text{N}}}$
Inputs	Channels A and B; can be common or separate
Display	ns and µs, decimal point automatically positioned

Multiple Ratio (Ratio $\frac{fA}{fB} \cdot N$)

Frequency range	
Input A (higher frequency)	DC . . . 160 MHz
Input B (lower frequency)	DC . . . 10 MHz
Multiplier (N)	1 . . . 10^7 (in decade steps)
Accuracy	± 1 count of fA $\pm \frac{\text{trigger error}^{*}\ \text{of fB}}{\text{N}}$
Display	dimensionless, decimal point automatically positioned

Count A (totalizing)

Range	10^9
Pulse repetition rate	DC . . . 160 MHz
Pulse resolution	2.5 ns minimum pulse width
Count accumulation	during only the first start/stop event or during repetitive start/stop events
Mode	start/stop by manual gate control or Count A gated by channel B
Input	channel A
Display	Dimensionless

Scaling ($\frac{fA}{N}$)

Range	scaling factor selectable from 1 . . . 10^9 (in decade steps)
Frequency range	DC . . . 10 MHz
Input	channel A
Output	same as time base output
Display	Dimensionless

Check

100 MHz counted during selected gate time. Functional test of logic circuits.

Display test

Functional test of all the decimal points, the measuring unit annunciators and the character segments.

Sub-unit

In the position "SUB-UNIT" the PM 6650 is programmed to accept sub-units such as the automatic microwave converter, prescaler etc.

B. INPUT CHARACTERISTICS

Input Channels A and B (not prescaled)

Frequency range	
DC coupled	DC . . . 160 MHz
AC coupled	30 Hz . . . 160 MHz
Pulse resolution	2.5 ns minimum pulse width
Sensitivity	
sine wave	50 mV_{rms} or 500 mV_{rms}
peak	150 mV_{p-p} or 1.5 V_{p-p}
Impedance	1 MΩ//25 pF or 50 Ω
Trigger window	About 80 mV hysteresis which is virtually eliminated in the TIME INTERVAL modes
Dynamic input voltage range	±3 V added to set trigger level voltage times attenuator setting
Coupling	AC or DC
Attenuation	× 1 or × 10
Trigger slope	+ or —
Trigger level	Preset to centre triggering 0 V or variable between —3 V . . . +3 V times attenuator setting
Trigger level monitor	Set trigger voltages available on miniature jacks (at front) and BNC (at rear)
Channel Inputs	Channel A and B; can be common or separate
Overload protection	230 V_{rms} $\leq$ 400 Hz or 300 V_{dc} in 1 MΩ positions 12 V_{rms} in the 50 Ω and in 1 MΩ position for frequencies $\geq$ 1 MHz
Connector	BNC

Input Channel C (not prescaled)

Frequency range	5 MHz . . . 512 MHz
Sensitivity	10 mV_{rms}
Impedance	50 Ω, nominal
Attenuation	automatic by AGC max 62 dB
AM modulation tolerance	99 % at modulation frequencies < 5 kHz 50 % at modulation frequencies 5 kHz — 10 kHz 30 % at modulation frequencies > 10 kHz
Coupling	AC
Level indication	LED indicates sufficient signal level for correct triggering
Overload protection	12 V_{rms}
Connector	BNC

External Reference Input

Frequency range	0.1 — 10 MHz
Impedance	1 kΩ//50 pF
Sensitivity	500 mV_{rms}
Coupling	AC
Overload protection	12 V_{rms}
Connector	BNC

C. OUTPUT CHARACTERISTICS

Trigger level output

Range	—3 V . . . +3 V
Impedance	4 kΩ in 0 V position
Overload protection	short circuit proof to earth
Connector	miniature jacks (at the front) BNC (at the rear)

Gate monitor ("GATE OPEN")

Provides Z-modulation output for observation of the measured interval.

Amplitude	approx. +0.4 V, when the gate is closed approx. +5 V, when the gate is open
Impedance	approx. 200 Ω
Delay	internal delay between the signal inputs and the trigger monitor output is approx. 50 ns
Overload protection	short circuit proof to earth
Connector	BNC

Time base out

Frequency	100 MHz . . . 0.01 Hz (in decade steps)
Amplitude	500 mV_{p-p} into 50 Ω
Impedance	approx. 100 Ω
Overload protection	short circuit proof to earth

Non-interrupted signal is available if the display time control is in "HOLD" position and in the functions: "FREQUENCY", "PERIOD", "TIME INTERVAL" and "CHECK".

10 MHz out

Amplitude	1 V_{rms} into 1 kΩ
Impedance	approx. 200 Ω
Overload protection	short circuit proof to earth
Connector	BNC

D. GENERAL CHARACTERISTICS

Display

Read out	9 digit planar display Leading zero blanking 10 mm high 7-segment numerals Decimal point indication
Memory	Switchable ON/OFF on front panel
Display time	50 ms . . . 5 s or infinite (HOLD) · Minimum externally controlled display time 3 ms
Reset	Pushing RESET button resets counter to zero
Unit annunciators	ns, μs, ms, kHz, MHz, GHz and NO-GO by read only memory programming
Gate lamp	LED indicates when the main gate is open and counting takes place
Osc	LED indicates, when power cord is connected, that oven-enclosed oscillator is on for initial stabilization
Remote	LED indicates when the instrument is remotely controlled. Remote control overrides manual control

Time base

Version	Oscillator	Ageing rate	Temperature stability	Stability at 10 % variation of mains voltage	Warm-up time
PM 6650 B	TCXO	$\pm 1\times10^{-7}$/month	$\pm 1\times10^{-8}$/°C avg.	$\pm 1\times10^{-9}$	None
PM 6650 A	PM 9680 A	$\pm 1.5\times^{-9}$/24 h*	$\pm 5\times10^{-10}$/°C avg.	$\pm 1\times10^{-10}$	**
PM 6650 E	PM 9681	$\pm5\times10^{-10}$/24 h *	$\pm 5\times10^{-10}$/°C avg.	$\pm 1\times10^{-10}$	**

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* Average, after 72 hours continuous operation

** Less than 7 minutes to within $\pm 10^{-7}$

Supply

Voltage	115 V or 230 V ±15 %, 50 . . . 400 Hz
Consumption	40 W (without any options and sub-units) 75 W (including PM 6634 and options) 5 W (in stand-by)

Temperature range

Operating range	0 . . . +45° C
Storage range	—40 . . . +70° C

	Table top Cabinet PM 9714 A	19″ rack mount Cabinet PM 9716 A
Dimensions		
Width	305 mm	445 mm
Height	132 mm	132 mm
Depth	404 mm	445 mm (incl. handles)
Weight	9.5 kg	11.5 kg

IV. ACCESSORIES, OPTIONS AND SUB-UNITS

1. Standard accessories supplied with the instrument

- 1 mains cable
- 1 manual
- 1 Allen wrench

2. Options, sub-units and accessories to be ordered separately

2.1. Oven-enclosed oscillators

PM 9680A	option for model PM 6650 B
PM 9681	option for models PM 6650 A and PM 6650 B

2.2. Data peripherals

PM 9684	BCD output unit
PM 9685	Remote control unit
PM 9686	Bus system interface
PM 9687	D/A Converter

2.3. Sub-units

PM 6632	Pre-scaler, 810 MHz
PM 6633	Pre-amplifier
PM 6634	Microwave converter, 12.6 GHz
PM 6636	Pre-scaler, 1 GHz

2.4. Input interface accessories

PM 9351	Passive measuring probe 10 MΩ//11 pF 220 MHz, attenuation 10×
PM 9353	FET probe, 1 MΩ//3.5 pF, 220 MHz
PM 9346	Power supply for PM 9353
PM 9584	Resistive mixing piece, 50 Ω, 3 BNC sockets
PM 9665	Low-pass filter with 3 BNC inputs: < 50 kHz, < 500 kHz, < 5 MHz.

2.5. Coaxial cables

PM 9074	50 Ω, BNC to BNC, length 1 m.
PM 9588	Set of 50 Ω cables, BNC to BNC: 5 cables, length 20.7 cm 4 cables, length 40.5 cm 3 cables, length 60.3 cm 3 cables, length 198.6 cm

2.6. Mains cable

PM 9011	3-core detachable mains cable.

2.7. Cabinets and blank panels (refer to chapter II for full details)

PM 9664	Rear panel for cabinet PM 9716 A
PM 9714A	Bench cabinet, 4/6 rack size
PM 9716A	19″ cabinet, 6/6 rack size
PM 9721	Blank panel, 1/6 rack size
PM 9722	Blank panel, 2/6 rack size

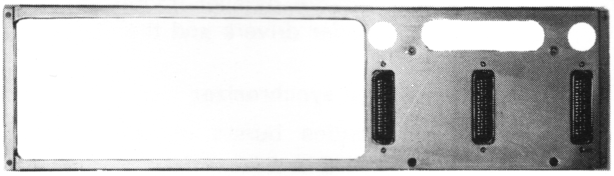


Figure IV-1. Rear panel PM 9664 for interconnection of counter and sub-unit

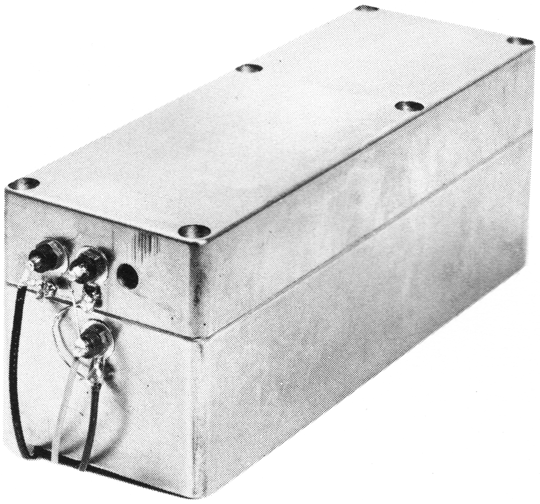


Figure IV-2. PM 9680 A, or PM 9681, crystal oscillator in proportionally controlled oven

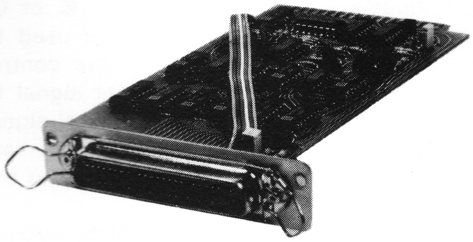


Figure IV-3. PM 9684, BCD output unit

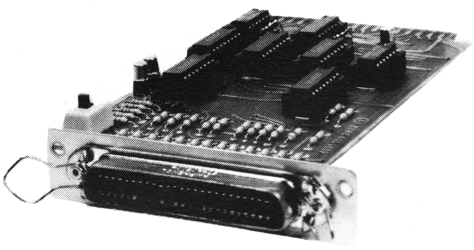


Figure IV-4. PM 9685, remote control unit

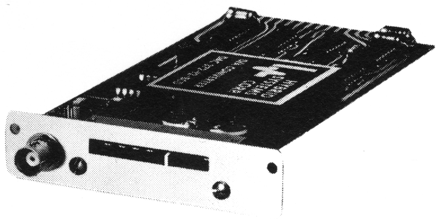


Figure IV-5. PM 9687, digital to analogue converter

V. BLOCK DIAGRAM DESCRIPTION

1. Input channels A and B

The PM 6650 has two identical input channels A and B, consisting of input conditioning circuits operated with front panel controls ATT., COUPLING, and SLOPE. An amplifier and trigger circuit shapes the signal which is routed to the Function Selector. The desired triggering level can be set with front panel control LEVEL and is accessible at output LEVEL OUT at the front and rear panels.

2. Input channel C

Channels C contains an automatic gain control circuit which keeps the output signal at an optimum level independent of the input amplitude. This signal is also fed to the Function Selector.

3. 10 MHz clock oscillator

The internal 10 MHz clock signal is fed through the external/internal selector circuit to the Function Selector. If an external clock is used, the internal clock is disconnected.

4. Function Selector

In general, two signals are routed to the Function Selector: the input signal from channels A, B, or C, and the clock signal. One of the signals is used to control the main gate. The first pulse of the control signal will open the gate allowing the other signal to pass through until the next pulse of the control signal is closing the gate. The information from the last counting interval is stored in the memories during the new counting interval.

When the main gate is closed, the control circuits generates a transfer pulse enabling the new information to pass on to the display. After the set display time, the decade counters are reset and a new measurement can start.

At time interval measurement, the start signal applied to channel A and the stop signal applied at channel B control the main gate via the Function Selector. The 10 MHz clock signal is multiplied to 100 MHz and counted during the start to stop interval.

5. Frequency dividers

At frequency measurement, the clock signal is scaled in the frequency dividers as determined by the TIME BASE switch. The scaled signal controls the main gate and the input signal applied to channel A or C is counted during the set gate time interval.

At period measurement, the signal from input A controls the main gate directly. The clock signal is multiplied to 100 MHz and is scaled in the frequency dividers. The scaling factor is set with the MULTIPLIER switch. The scaled signal is then counted during an interval determined by the input A signal.

In period averaging situations, the A signal is scaled in the frequency dividers and used to control the main gate. The 10 MHz clock signal is multiplied to 100 MHz and counted during an interval determined by the scaled input signal.

6. Decade counters, memories and display

The fastest HF decade provides the most significant digit to the memories and the TTL decades the remaining digits in parallel form. The memories are shift registers which convert the parallel information into serial form for the decoder drivers and the display.

7. Time interval average synchronizer

The synchronizer provides bursts of clock pulses which are counted during a time determined by the MULTIPLIER switch. The number of clock pulses within each burst corresponds to the average time interval between signals A and B. The MULTIPLIER setting represents the number of averagings selected.

A detailed description is given in the Service Manual.

VI. INSTALLATION

1. Cabinets

Two types of cabinets are available for the PM 6650:
- — a bench cabinet (4/6 rack size)
- — a 19″ cabinet (6/6 rack size)

Refer to chapter II for full details.

1.1. Bench cabinet

Proceed as follows to fit counter in cabinet (refer to fig. VI-1):
- — Loosen Allen screws “A”.
- — Press knurled part of quick-release cams “B” so that they hinge out.
- — Slide counter into cabinet, press release cams and tighten screws “A”.

1.2. 19″ cabinet
- — Remove rear plastic cover.
- — Fit the dark grey plastic rails to cross-bars located at 4/6 distance from left-hand side of cabinet (refer to fig. VI-2).
- — Mount rear panel PM 9664 with four screws A (fig. VI-3).
- — Slide counter into cabinet, press and secure release cams.

NOTE: If no sub-unit is used, the empty compartment can be covered by blank panel PM 9722 (2/6 rack size) or two blank panels PM 9721 (1/6 rack size).

1.3. Rack installation

The rear plastic cover of the 19″ cabinet contains two angular brackets for rack mounting.

Refer to fig. VI-2 and proceed as follows:
- — Remove four screws 1.
- — Slightly lift side plates at front and remove plastic plates 2.
- — Mount angular brackets in the place of the plastic plates.
- — Refit side plates and secure with screws 1.
- — Remove feet 3.
- — Remove tilting bracket and two pivot brackets.

2. Sub-unit installation

2.1. The desired sub-unit is installed in the 2/6 compartment of the 19″ cabinet. The sub-unit is connected to the PM 6650 via rear panel PM 9664 and a front panel coaxial cable.

Proceed as follows:
- — Switch off power.
- — Push sub-unit into compartment until front panel is flush with counter.
- — Press and secure release cam.
- — Interconnect sub-unit output and relevant input of PM 6650 using a coaxial cable (refer to operating instruction of sub-unit).

3. Installing BCD output unit PM 9684 and remote control unit PM 9685

3.1. BCD output unit PM 9684 (refer to fig. VI-4 and fig. VI-5).
- — Remove rear cover plate A.
- — Plug unit into connector C.
- — Secure unit to rear panel with the two screws supplied.

3.2. Remote control unit PM 9685 (refer to fig. VI-4 and fig. VI-6).
- — Remove rear plate B.
- — Plug unit into connector D.
- — Secure unit to rear panel with the two screws supplied.

4. Installing D/A converter PM 9687

- — Remove rear cover plate A (fig. VI-4).
- — Plug unit into connector C (fig. VI-7).
- — Secure unit to rear panel with the two screws supplied.

5. Installing oven-enclosed oscillators PM 9680 A or PM 9681

5.1. Model PM 6650 B can be equipped with optional oscillator PM 9680 A or the ultra-stable type PM 9681 (refer to chapter II for full details).

The PM 9681 can also be installed in model PM 6650 A.

5.2. Proceed as follows (refer to fig. VI-8):
- — Unplug TCXO.
- — Fasten oscillator box to left-hand side wall with the four screws supplied.
- — Connect coaxial cable to connector BU616 and supply leads to earth and +12 V.
- — Let the PM 6650 warm up for at least 7 minutes before measuring.

6. Mains voltage conversion and rear panel fuse

The PM 6650 can be adapted to two mains voltage ranges as shown in table VI-1. The mains voltage selector (refer to fig. VII-2) is operated with a screwdriver inserted in the switch slot.

At delivery the PM 6650 is set to 230 V and provided with a 0.5 A slow-blow fuse in the rear panel fuseholder (refer to fig. VII-2). Be sure to change fuse to 1 A, slow-blow, if 115 V range is selected!

Mains voltage range	*slide switch*	*marking visible*	*fuse*
200 . . . 260 V	downwards	115 V	0.5 A slow-blow
100 . . . 130 V	upwards	230 V	1 A slow-blow

Mains frequency range is 50 Hz to 400 Hz.

7. Internal fuses

Two more fuses protecting the power supply are accessible inside the PM 6650 on unit U6. Refer to fig. VI-9. Both fuses are 2 A, normal.

Refer to the Service Manual to isolate fault causing fuses to blow.

8. Earthing

The local safety regulations prescribe how the PM 6650 should be earthed. Two ways are possible:
- a) via the 3-core mains cable plugged into an outlet with protective earth contact.
- b) via the protective earth terminal on the rear panel (fig. VII-2).

NOTE: Use only *one* of these alternatives, otherwise hum may occur.

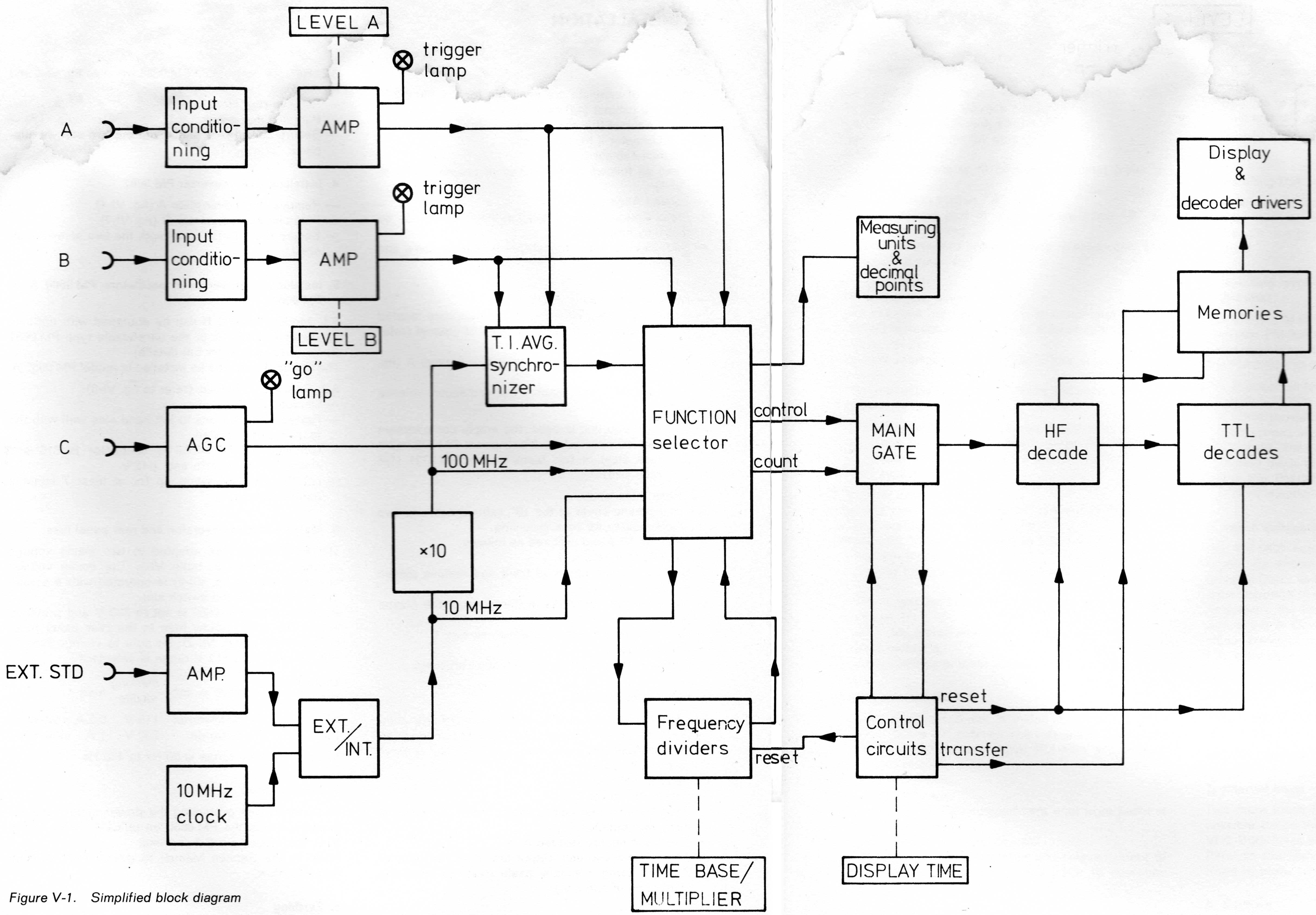


Figure V-1. Simplified block diagram

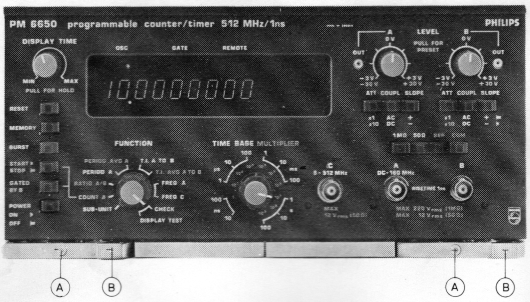


Figure VI-1. Installing the PM 6650 in bench cabinet

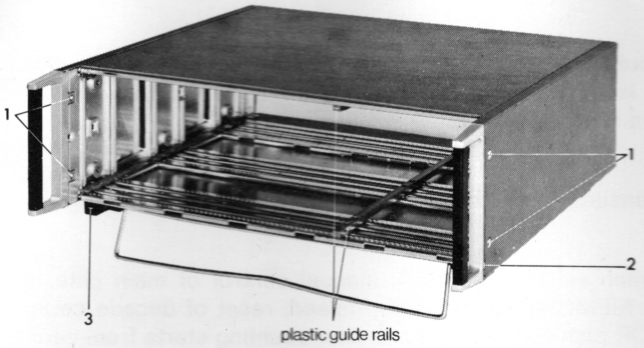


Figure VI-2. Mounting the brackets for rack installation

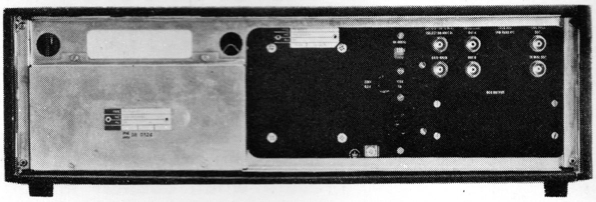


Figure VI-3. 19" cabinet provided with rear panel PM 9664

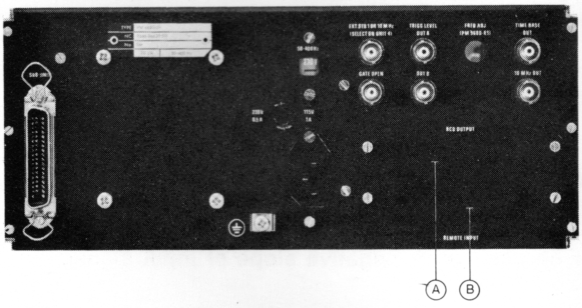


Figure VI-4. Inputs for optional cards

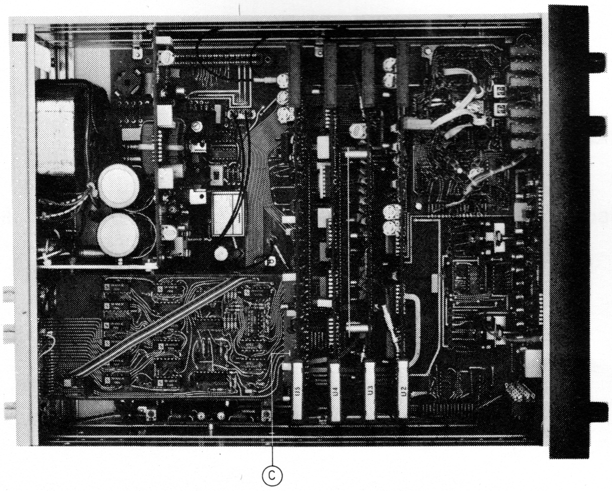


Figure VI-5. Plugging in BCD output unit PM 9684

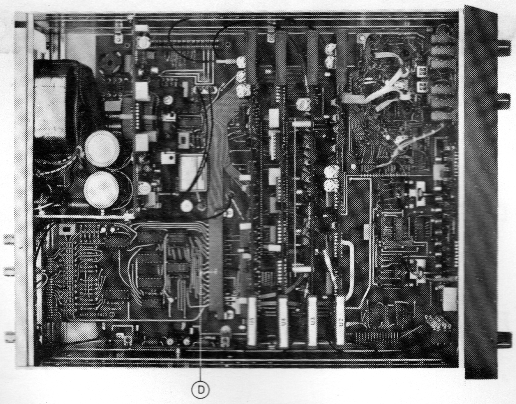


Figure VI-6. Plugging in remote control unit PM 9685

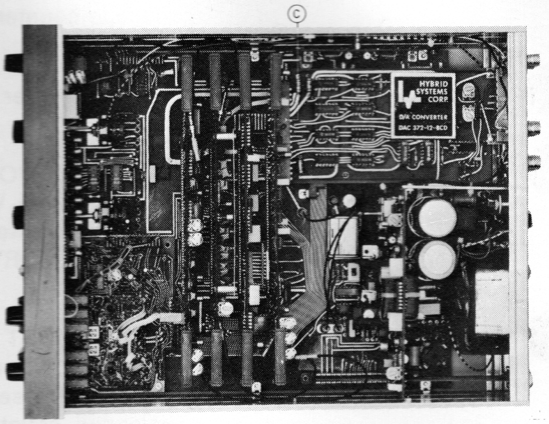


Figure VI-7. Plugging in DAC PM 9687

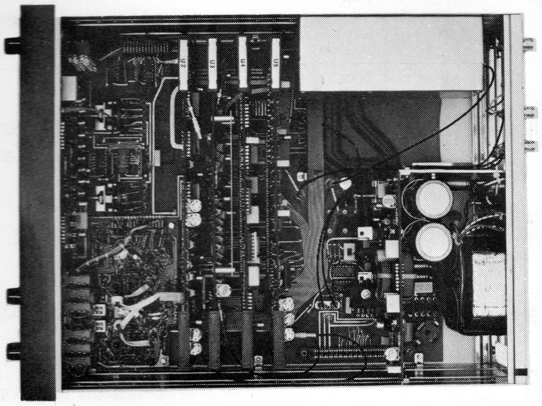


Figure VI-8. Mounting optional oscillator PM 9680 A or PM 9681

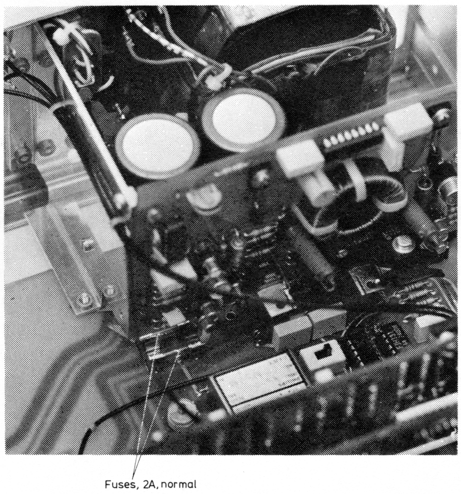


Figure VI-9. Internal fuses

VII. CONTROLS, INDICATORS AND CONNECTORS

Figure VII-1

❶ **DISPLAY TIME**	Sets display time between 0.05 s to 5 s. Infinite display time when knob is pulled to HOLD position.
❷ **RESET**	Resets decade counters and display to zero. Starts new measurement when released.
❸ **MEMORY**	When button is depressed, measurement information is stored until next measurement cycle is completed. Released button makes display follow decade counters continuously.
❹ **BURST**	Allows counter to measure burst signals in mode FREQ. A or FREQ. C.
❺ **START/STOP**	With FUNCTION switch set to COUNT A, manual control of main gate in totalize mode. When MEMORY switch is depressed, reset of decade counters occurs after STOP plus set display time; new counting starts from zero. When MEMORY is released, counting is cumulative.
❻ **GATED BY B**	In the COUNT A mode, the signal at INPUT A can be gated by signal at INPUT B. When MEMORY switch is depressed, reset of decade counters occurs after set display time when gating pulse ends. When MEMORY is released, counting is cumulative.
❼ **POWER ON/OFF**	Secondary power switch. Turns d.c. voltages of circuitry on/off. A.C. voltages and oven-enclosed oscillator supply present when counter is connected to mains.
❽ **A LEVEL**	Sets trigger level of channel A to ±3 V or ±30 V when the ATT switch is set to ×10. Level is preset to zero when knob is pulled.
❾ **ATT**	Provides 10× attenuation of signal at INPUT A.
❿ **COUPLING**	Selector for AC or DC coupled input.
⓫ **SLOPE**	Enables triggering either on positive or negative slope of input signal.
⓬ **1 MΩ**	Sets 1 MΩ input impedance of channels A and B.
⓭ **50Ω**	Sets 50Ω input impedance of channels A and B.
⓮ **SEP**	Separates inputs A and B.
⓯ **COM**	Connects A signal also to B channel. If selected, 50Ω input impedance is maintained.

⑯ FUNCTION

Operation mode selector. Blue text corresponds to blue text at TIME BASE/ MULTIPLIER switch.

Positions:

SUB-UNIT	Matches counter to sub-unit used.
COUNT A	Sets counter to totalize or scaling mode (see also controls 5 and 6). Signal applied to INPUT A is scaled by a factor 1 to 10^9 as set with MULTIPLIER switch. Scaled signal available at rear TIME BASE OUT connector. Frequency range in totalize mode 0 to 160 MHz, in scaling mode 0 to 10 MHz.
RATIO A/B	Used when measuring ratio of frequency A (0 to 160 MHz) applied at INPUT A to frequency B (0 to 10 MHz) applied at INPUT B.
PERIOD A	Sets counter to measure single period applied at INPUT A. Desired resolution 10 ns to 1 s is set with TIME BASE switch. Frequency range 0 to 10 MHz.
PERIOD AVG A	Sets counter to measure period of signal applied at INPUT A. MULTIPLIER switch sets number of periods (1 to 10^8) to be averaged. Frequency range 0 to 10 MHz.
T.I. A TO B	Sets counter to measure time interval A to B, with start signal at INPUT A and stop signal at INPUT B. TIME BASE switch sets counted frequency (100 MHz to 1 Hz). Input range is 40 ns to 10^9 s. Inputs A and B can be common or separated. A deadtime of $\geq$ 50 ns between interval is required.
T.I. AVG A TO B	Sets counter to measure average interval A to B, with start signal at INPUT A and stop signal at INPUT B. Input range is 100 ps to 10 s, repetition rate 10 MHz. MULTIPLIER switch sets number of intervals to be averaged (1 to 10^8). A dead-time of $\geq$ 50 ns between intervals is required.
FREQ. A	Sets counter to measure frequency of signal applied to INPUT A. TIME BASE switch sets suitable gate time (100 ns to 100 s). See also 20. INPUT A.
FREQ. C	Sets counter to measure frequency of signal applied to INPUT C. TIME BASE switch sets suitable gate time (100 ns to 100 s). See also 18. INPUT C.
CHECK	Used for self-check of internal logic circuits. Counter displays 100 MHz (derived from internal oscillator) during gate time set with TIME BASE switch.
DISPLAY TEST	Used to check function of decimal points, measuring unit display and character segments. Each step up to 1 s of TIME BASE/MULTIPLIER switch provides one functional test.

⑰ TIME BASE/MULTIPLIER

Function depends on set operating mode:

FUNCTION:	*TIME BASE/MULTIPLIER:*
SUB-UNIT	Depends on sub-unit used. Refer to relevant operating manual.
COUNT A	Sets scaling factor 1 to 10^9 for signal applied at INPUT A and available at rear TIME BASE OUT connector.
RATIO A/B	Sets multiplying factor 1 to 10^7.
PERIOD A	Selects scaling factor for internal or external oscillator signal.
PERIOD AVG A	Sets number of periods to be averaged.
T.I. A TO B	Selects scaling factor for internal or external oscillator signal.
T.I. AVG A TO B	Sets number of time intervals to be averaged.
FREQ. A and FREQ. C	Selects gate time.
CHECK	Selects gate time.
DISPLAY TEST	Selects 8 functional tests (cw rotation from 10 ns) of decimal points, unit display and character segments.

⑱ **Input C**	Input connector for channel C. Frequency range is 5 to 512 MHz, sensitivity 10 $\mathrm{mV_{rms}}$. Input impedance is 50 Ω; AGC circuit provides automatic attenuation. Maximum input voltage is 12 $\mathrm{V_{rms}}$.
⑲	Light-emitting diode turns on when input level is sufficient for correct triggering.
⑳ **Input A**	Input connector for channel A. Frequency range is 0 to 160 MHz when DC coupled, 30 Hz to 160 MHz when AC coupled. Impedance can be set to 1 MΩ shunted by 25 pF or to 50 Ω. Dynamic range is ±3 V compared to set trigger level times attenuator setting. Trigger level is available at front panel miniature jacks and BNC connectors at rear panel. Maximum input voltage is 230 $\mathrm{V_{rms}}$ or 230 V d.c. at 1 MΩ, and 12 $\mathrm{V_{rms}}$ at 50 Ω.
㉑ **Input B**	Same as 20. Input A but accepts also gating signal for channel A in totalize mode.
㉒	Light-emitting diode turns on during 100 ms when triggering level is passed.
㉓ **A OUT**	Provides set triggering voltage from channel A.
㉔ **OSC**	Light-emitting diode turns on when mains cable is connected to mains. Indicates that oven-enclosed oscillator circuits are connected to supply voltage.
㉕ **GATE**	Light-emitting diode indicates when main gate is open (on) and closed (off).
㉖ **REMOTE**	Light-emitting diode turns on when counter is programmed externally via remote control unit, e.g. option PM 9685.
㉗	Unit annunciator indicates measuring unit. "No go" is indicated at impossible combinations of control settings.

Rear panel switch and connectors *Figure VII-2*

㉘ **230 V** **115 V**	Mains voltage selector.
㉙	Mains input.
㉚ **SUB-UNIT**	Sub-unit connector. Fits connector of rear panel PM 9664 in 19" cabinet PM 9716 A.
㉛ **TIME BASE OUT**	Output signal depends on operating mode set with FUNCTION switch: COUNT A: Scaled signal. Scaling factor set with MULTIPLIER switch. PERIOD A or T.I. A TO B: Output signal 100 MHz to 0.01 Hz. CHECK: 100 MHz signal gated by set TIME BASE (DISPLAY TIME control pulled). Amplitude is 500 $\mathrm{mV_{pp}}$ in 50 Ω; source impedance approx. 100 Ω, DC coupled.

㉜	**10 MHz OUT**	Provides internal oscillator signal even if external standard frequency is used. Amplitude is 1 V_{rms} in 1 kΩ and source impedance approx. 200 Ω, DC coupled.
㉝	**TRIGG. LEVEL OUT**	Provides trigger level of channel A. Amplitude is +3 V to —3 V as set with front panel control LEVEL A. Impedance is 4 kΩ. Set level equals measured value independent of load.
㉞	**EXT STD 1 OR 10 MHz**	Accepts external frequency standard. Internal switch of unit 4 can be set to match counter to 1 MHz or 10 MHz standards. 10 MHz must be used if time resolution better than 1 μs is required. 100 kHz signal can be applied but correct position of decimal point must then be calculated. Impedance is 1 kΩ shunted by 50 pF, AC coupled. Sensitivity is 500 mV_{rms} and maximum input voltage 12 V_{rms}.
㉟	**GATE OPEN**	Provides signal when main gate is open. Can be used as a Z-modulation signal in single period, single time interval and frequency burst operating modes. Amplitude is approx. +0.4 V when main gate is closed and approx. +5 V when main gate is open. Impedance is 200 Ω. Delay from input A to GATE OPEN is about 50 ns.
㊱		Clamp for protective ground.
㊲		Fuse holder.

Internal switches and connectors *Figure VII-3*

㊳	**INT.STD/EXT.STD**	Sets counter to operate with internal or external clock oscillator.
㊴	**10 MHz STD/1 MHz STD**	Sets counter to accept 10 MHz or 1 MHz external clock frequency.
㊵		Input connector for 10 MHz signal from optional oscillator PM 9680 A or PM 9681.
㊶		Connector for optional remote control unit PM 9685.
㊷		Connector for optional BCD output unit PM 9684 or digital to analogue converter PM 9687.

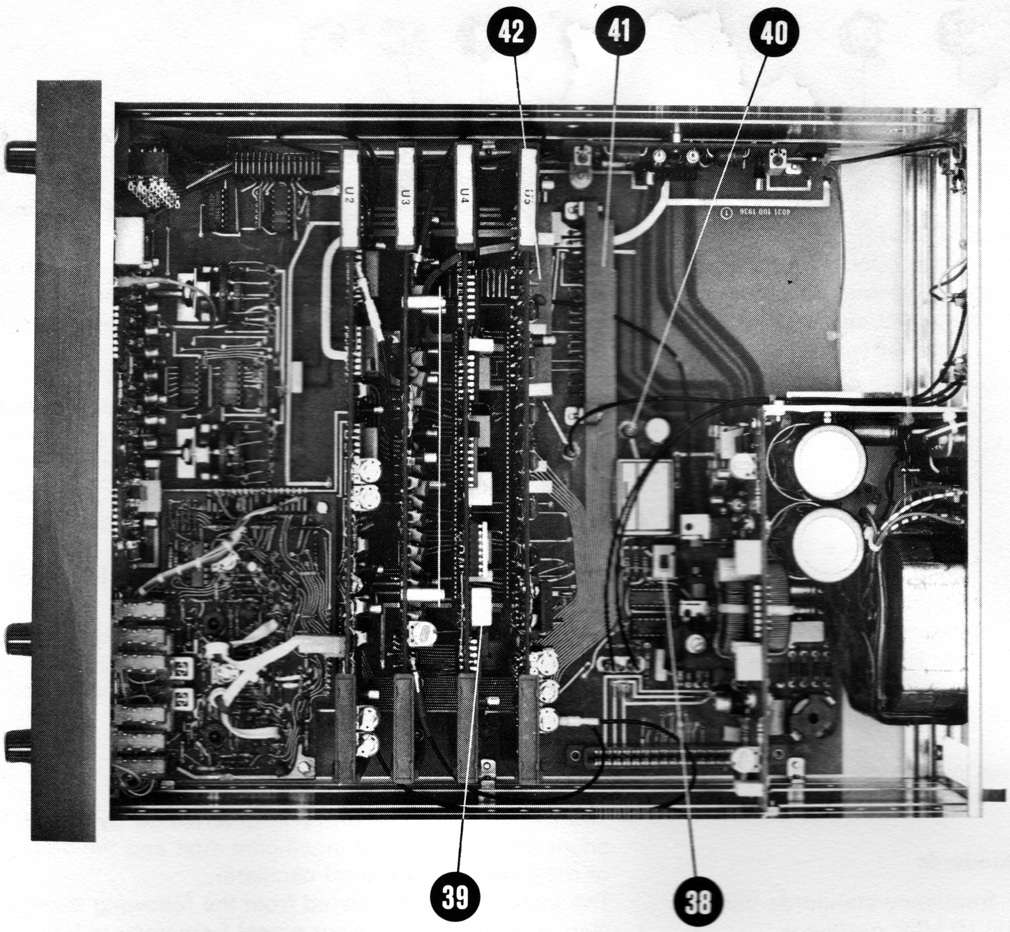


Figure VII-3. Internal switches and connectors

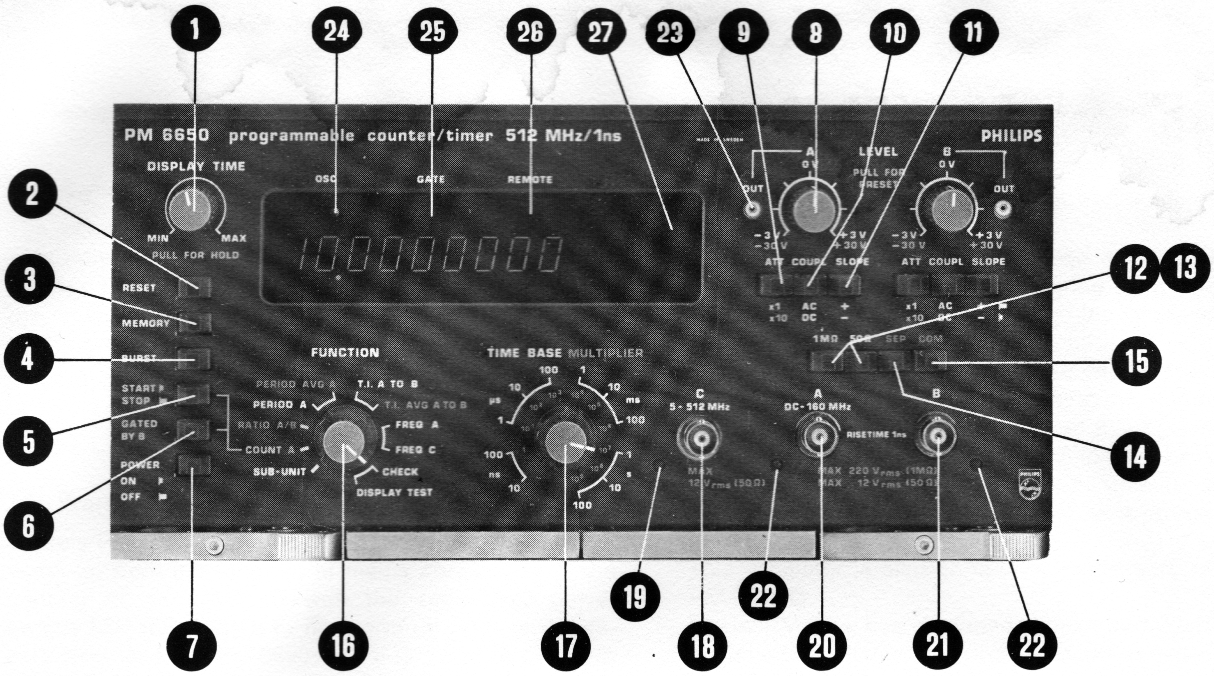


Figure VII-1. Front panel controls and connectors

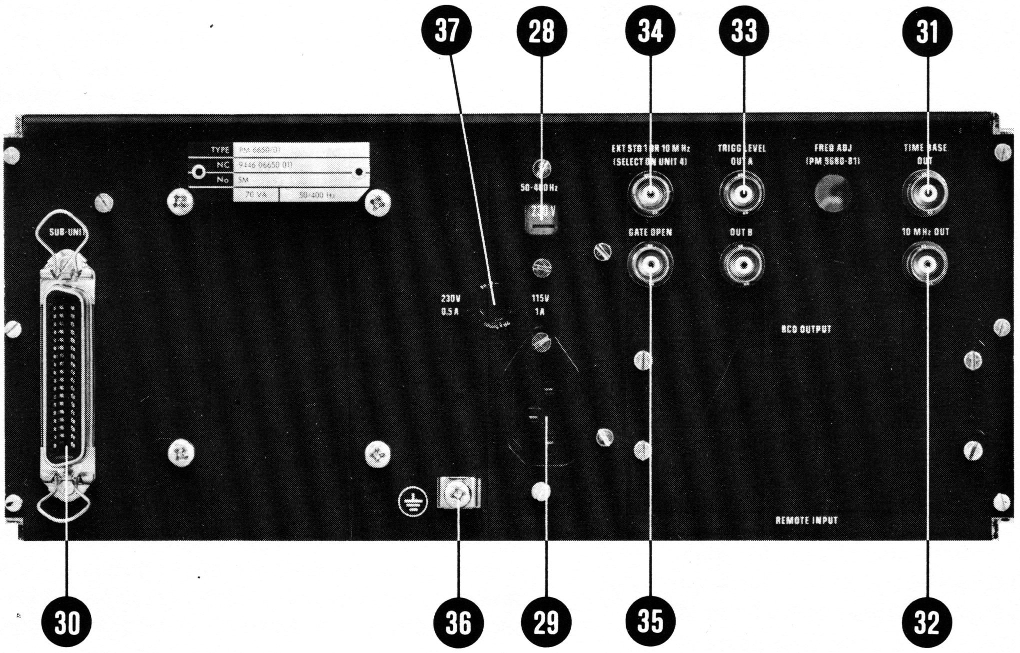


Figure VII-2. Rear panel controls and connectors

VIII. OPERATION

1. General information

1.1. Switch on power

The secondary power switch POWER ON/OFF operates only the DC voltages of the circuitry. The oven-enclosed oscillator, however, is operating as soon as the mains cable is connected to the mains. The light-emitting diode marked OSC then turns on.

WARNING: Check that counter is set to correct mains voltage before POWER ON is depressed! (Refer to section VI-6).

1.2. Warm-up;time

Models PM 6650 A and PM 6650 E require 7 minutes of warm-up from the moment of mains connection. If the counter is switched off with the secondary power switch POWER ON/OFF, no warm-up time is necessary next time the PM 6650 A or E is going to be used.
Model PM 6650 B needs no warm-up time unless it has later on been equipped with optional oscillator PM 9680 A or PM 9681.
In such a case the same prescriptions as for the PM 6650 A and E apply.

1.3. External frequency standards

House standards or other frequency standards can be used instead of the internal 10 MHz oscillator.
The frequency can be 1 MHz or 10 MHz.
If a time resolution of better than 10 μs is required, 10 MHz should be used.
Proceed as follows to set counter to external operation (refer to fig. VII-3):
— Set switch A to EXT.
— Select 1 MHz or 10 MHz using switch B.
— Apply external standard to rear input EXT.STD.

NOTE: 100 kHz can be used if switch B is set to 1 MHz. To interpret the display, shift shown decimal point one step to the left.

1.4. Measurement accuracy

1.4.1. Basic error types
In digital counters there are three basic error types whose significance depends on which measuring mode is selected:
the ±1 count ambiguity, the trigger error and the time base stability.
The *±1 count error* is inherent in all digital counters. It occurs because the input signal is not synchronised with the gate operation. Its significance is reduced in period average or time interval average measurements. For example, in period average measurement, the

$$\text{error is } \pm \frac{\text{input signal frequency}}{\text{time base frequency} \times \text{periods averaged}}$$

The *trigger error* is caused by the noise superimposed on the input signal and by the inherent noise of the input amplifiers and trigger circuits. This noise will give rise to a width variation of the conditioned input signal used to operate the main gate in the period and time interval modes. For signals with a signal to noise ratio of 40 dB or better and at rated sensitivity, the trigger error can be expressed as $\frac{3\times10^{-3}}{N}$, where N is the number of periods averaged.
The trigger error is insignificant in frequency, ratio and totalize measurements.
The error caused by the *time base stability* will be a limiting factor only when measuring long time intervals, which means that in practice the time base error can be ignored.
The PM 6650 has a choice of three oscillators:
Model PM 6650 B has a temperature compensated crystal oscillator (TCXO) having an average ageing of $\pm8\times10^{-7}$/year after 3 months of initial ageing.
Model PM 6650 A features a high-stability oven-enclosed oscillator, PM 9680 A, with an average ageing of $\pm1.5\times10^{-9}$/24 h.
This oscillator is also an optional accessory for model PM 6650 B.
Model PM 6650 E is equipped with an ultra-stable oven-enclosed oscillator, PM 9681 with an average ageing of $\pm5\times10^{-10}$/24 h. This oscillator is an optional accessory for models PM 6650 A and PM 6650 B.

1.4.2. Frequency measurement

The measurement accuracy is determined by the ±1 count error of the least significant digit and the ageing of the internal or external oscillator.
The error can be calculated from the following expression in which f is the input signal frequency in Hz:

$$\text{error} = \pm \frac{1}{f \times \text{gate time (s)}} \pm \text{time base error.}$$

The measurement error for various gate time settings of models PM 6650 A, B, and E is given in the diagrams figures VIII-1 and VIII-2.

1.4.3. Period measurement

All of the three basic errors can influence the accuracy of period measurement. The period average mode, however, reduces the significance of the ±1 count error and the trigger error.
The measurement error of the PM 6650 A and E and PM 6650 B in the period average mode is plotted in the diagrams figure VIII-1 and figure VIII 2.
The following formula expresses the error:

$$\text{error} = \pm \frac{f_2}{N\times f_1} \pm \frac{e_T}{N} \pm e_{osc.}$$

f_1 = time base frequency counted (= 100 MHz in PERIOD AVERAGE)
f_2 = input signal frequency
N = number of periods averaged
e_T = trigger error ($=3\times10^{-3}$/period for signals with S/N of 40 dB at rated sensitivity)
e_{osc} = average time base ageing rate
(PM 6650 A = $\pm1.5\times10^{-9}$/24 h
PM 6650 B = $\pm1\times10^{-7}$/month
PM 6650 E = $\pm5\times10^{-10}$/24 h)

1.4.4. Time interval measurement

The significance of the ±1 count and trigger errors is reduced in averaging situations. The accuracy of a time interval average measurement can be expressed

as

$$\pm \frac{\pm 1 \text{ count } \pm \text{ trigger error}}{\sqrt{N}} \pm \text{ time base error}$$

in which N is the number of intervals averaged.
Since the ±1 count error is equal to the period of the internal oscillator, which is actually 10 ns for the PM 6650, the significance of this error is considerably reduced.
In practice also a systematical error must be added. This error originates mainly from the rise time of the input amplifiers and is ±1 ns for the PM 6650.
Although the PM 6650 is a direct-gated counter, biased T.I. average measurement is prevented by a synchronizing circuit.

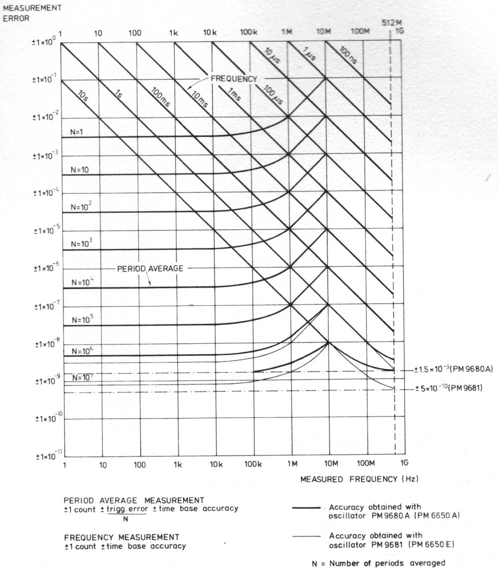


Figure VIII-1. *Measurement error vs frequency and period, PM 6550 A and E*

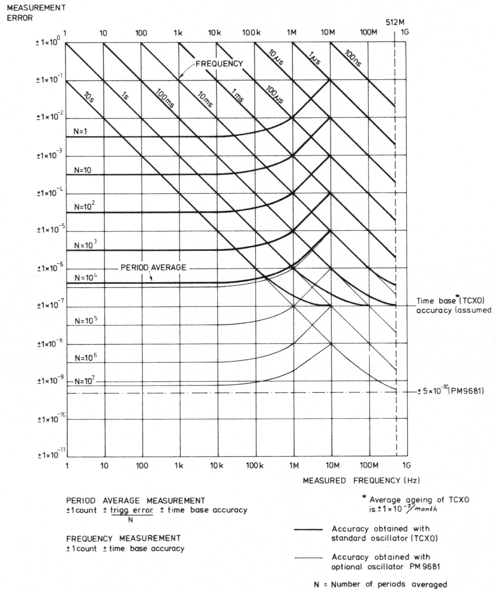
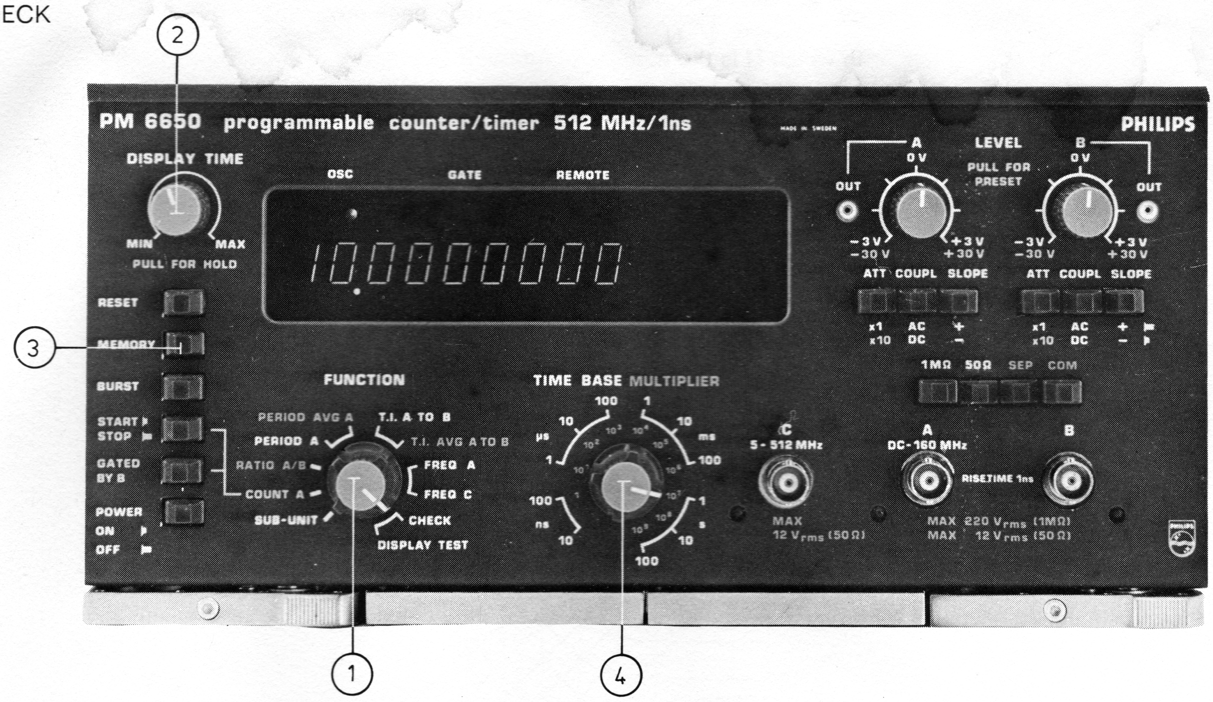


Figure VIII-2. *Measurement error vs frequency and period, PM 6650 B.*

2. Measurements

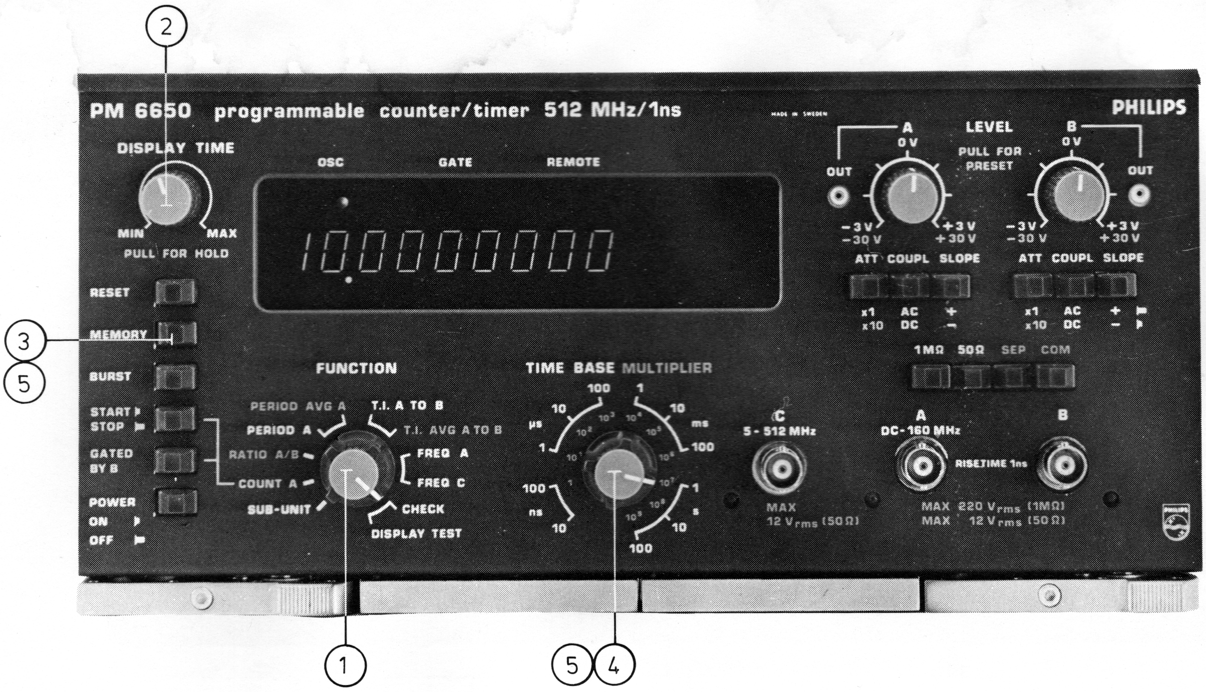
2.1, CHECK



1. Set FUNCTION to CHECK.
2. Set DISPLAY TIME to mid-position.
3. Depress MEMORY switch.
4. Rotate TIME BASE switch and read displayed value as follows:

TIME BASE	Read (±1 digit)
10 ns	0. No go
100 ns	0.10 GHz
1 µs	100 MHz
10 µs	100.0 MHz
100 µs	100.00 MHz
1 ms	100.000 MHz
10 ms	100.0000 MHz
100 ms	100.00000 MHz
1 s	100000.000 kHz
10 s	0.0000 kHz
100 s	0.00000 kHz

2.2. DISPLAY TEST

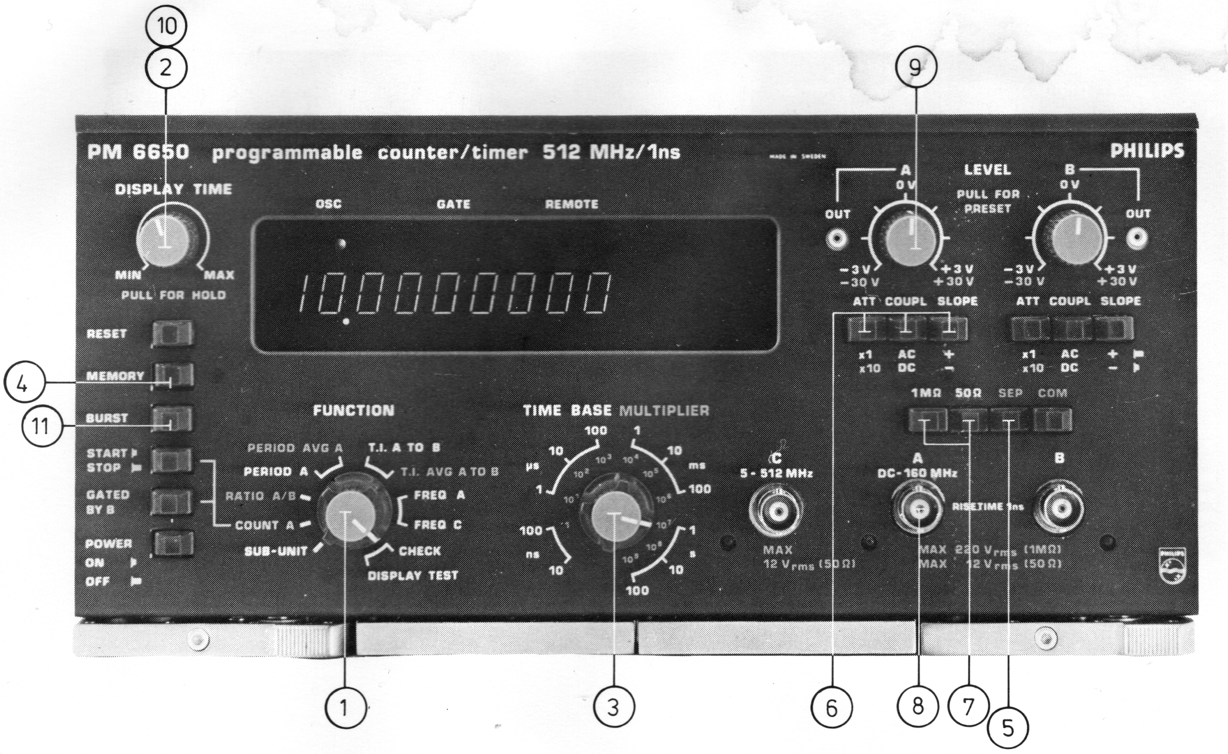


1. Set FUNCTION to DISPLAY TEST.
2. Set DISPLAY TIME to mid-position.
3. Depress MEMORY switch.
4. Rotate TIME BASE/MULTIPLIER switch from 10 ns to 1 s and check units and decimal points:

TIME BASE	Read (±1 digit)	GATE lamp flashing
10 ns	0. ns	
100 ns	1.0 us	×
1 μs	1.00 ms	×
10 μs	1.000 s	×
100 μs	1.0000 GHz	×
1 ms	1.00000 MHz	×
10 ms	1.000000 kHz	×
100 ms	1.0000000 No go	×
1 s	1.00000000 No go	×

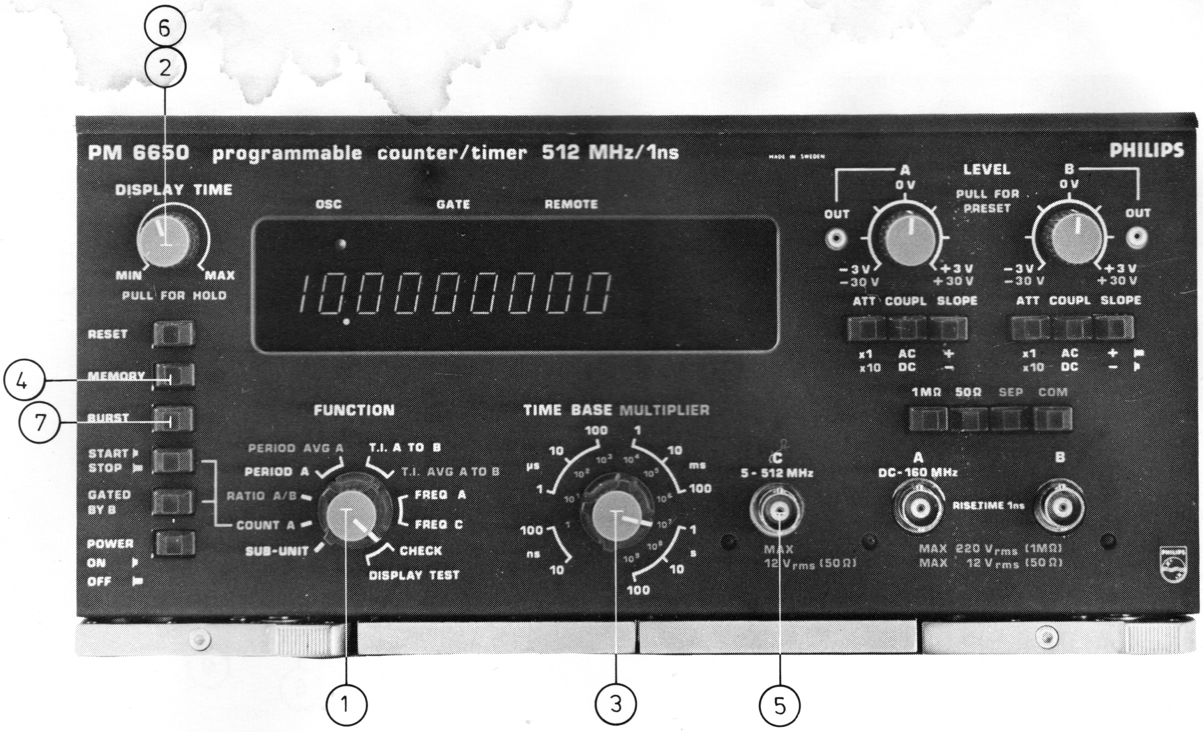
5. Check character segments:
   — Set TIME BASE switch to 10 s.
   — Release MEMORY switch.

2.3. FREQUENCY A measurement



1. Set FUNCTION switch to FREQ A.
2. Set DISPLAY TIME to mid-position.
3. Set TIME BASE switch to a suitable gate time.
4. Depress MEMORY switch.
5. Depress SEP switch.
6. Select desired input conditions of channel A (attenuation, coupling, slope).
7. Select suitable input impedance.
8. Apply signal to input A (0 to 160 MHz DC coupled, 30 Hz to 160 MHz AC coupled).
9. Adjust LEVEL A control until stable display is obtained and lamp at input lights permanently. Pull knob to PRESET if triggering at zero volts is desired.
10. Adjust DISPLAY TIME to desired position.
11. Depress BURST switch to measure burst signals, e.g. a pulsed carrier.

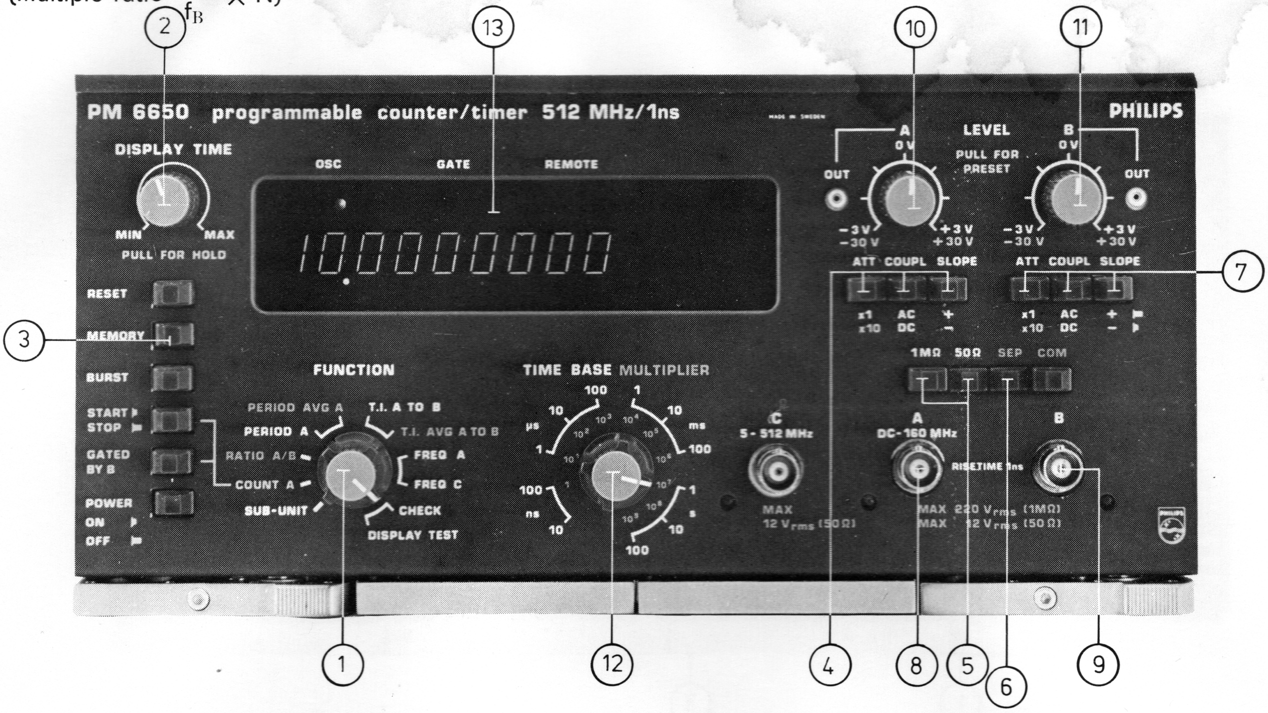
2.4. FREQUENCY C measurement



1. Set FUNCTION switch to FREQ C.
2. Set DISPLAY TIME to mid-position.
3. Set TIME BASE switch to a suitable gate time.
4. Depress MEMORY switch.
5. Apply signal to input C (5 to 512 MHz)
6. Adjust DISPLAY TIME to desired position.
7. Depress BURST switch to measure burst signal, e.g. a pulsed carrier.

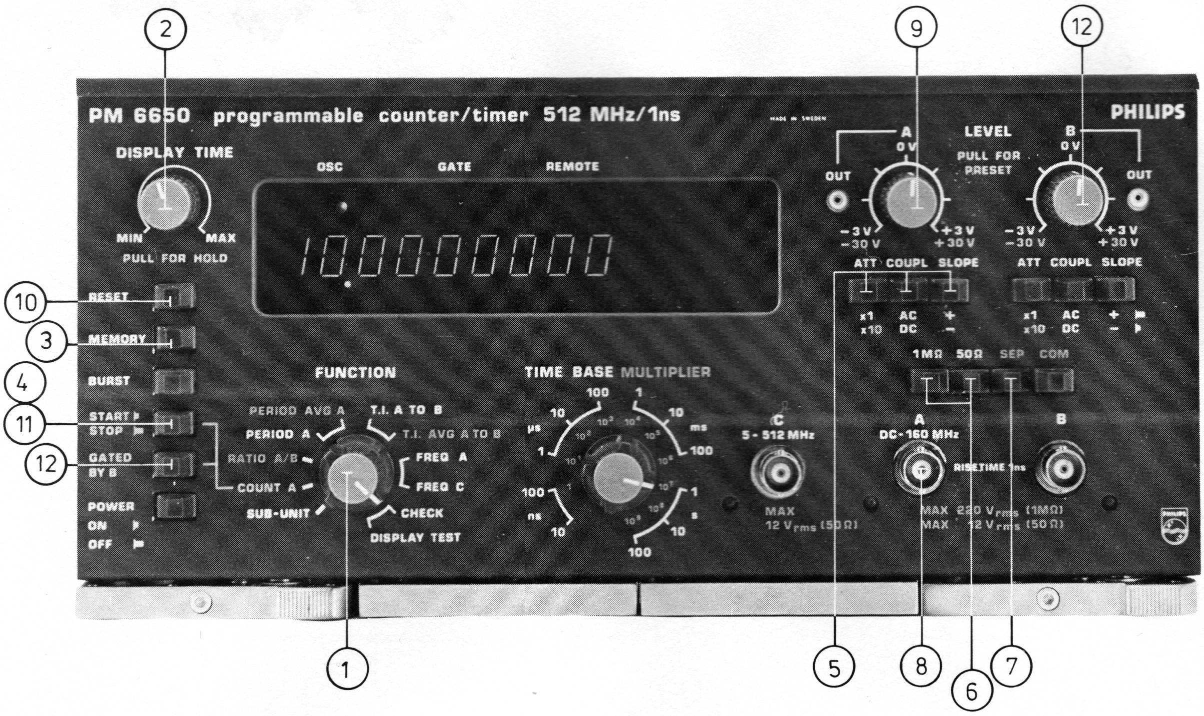
2.5. RATIO A TO B measurement

(multiple ratio $\frac{f_A}{f_B} \times N$)



1. Set FUNCTION switch to RATIO A/B.
2. Set DISPLAY TIME to mid-position.
3. Depress MEMORY switch.
4. Select desired input conditions of channel A (attenuation, coupling, slope).
5. Select suitable input impedance.
6. Depress SEP switch.
7. Select desired input conditions of channel B (attenuation, coupling, slope).
8. Connect signal with higher frequency (f_A, 0 to 160 MHz) to input A.
9. Connect signal with lower frequency (f_B, 0 to 10 MHz) to input B.
10. Set LEVEL A control for proper triggering level of channel A (lamp at input lights permanently).
11. Set LEVEL B control for proper triggering level of channel B (lamp at input lights permanently).
12. Set TIME BASE/MULTIPLIER switch to desired multiplying factor N (1 to 10^7).
13. Read result direct on display.

2.6. TOTALIZE MEASUREMENT

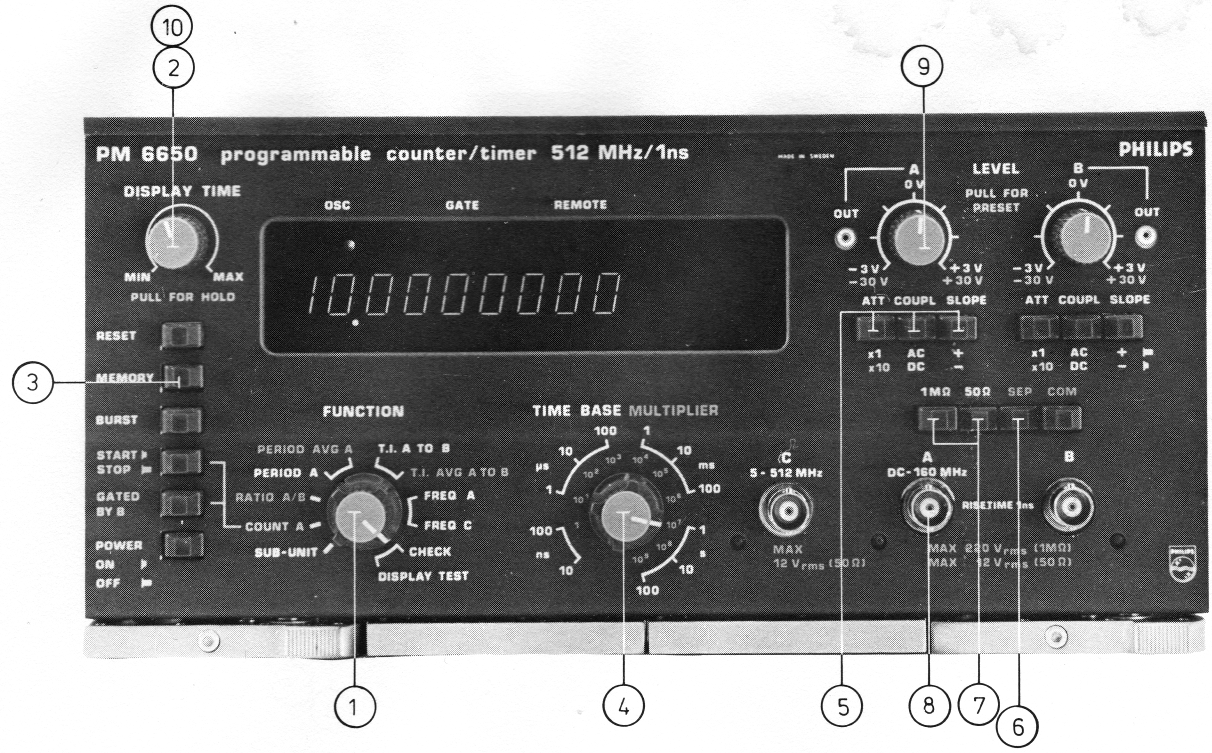


1. Set the FUNCTION switch to COUNT A.
2. Set DISPLAY TIME to mid-position.
3. Set MEMORY on or off (refer to NOTE 1 below).
4. Set START/STOP switch to STOP.
5. Select desired input conditions of channel A (attenuation, coupling, slope).
6. Select suitable input impedance.
7. Depress SEP switch.
8. Apply signal to input A (0 to 160 MHz DC coupled, 30 Hz to 160 MHz AC coupled).
9. Adjust LEVEL A control until display is stable and lamp at input lights.
10. Depress RESET switch.
11. Operate main gate with START/STOP switch (START: main gate opens. STOP: main gate closes).
12. Alternatively, depress switch GATED BY B and apply gating signal to channel B for electronic control of main gate. Frequency of gating sginal 0 to 10 MHz (DC coupled) or 30 Hz to 10 MHz (AC coupled).

NOTE 1: Counting is cumulative if MEMORY is off (button released). If MEMORY is on (button depressed), reset of decade counters occurs after set display time when START/STOP switch is set to STOP. New counting starts from zero.

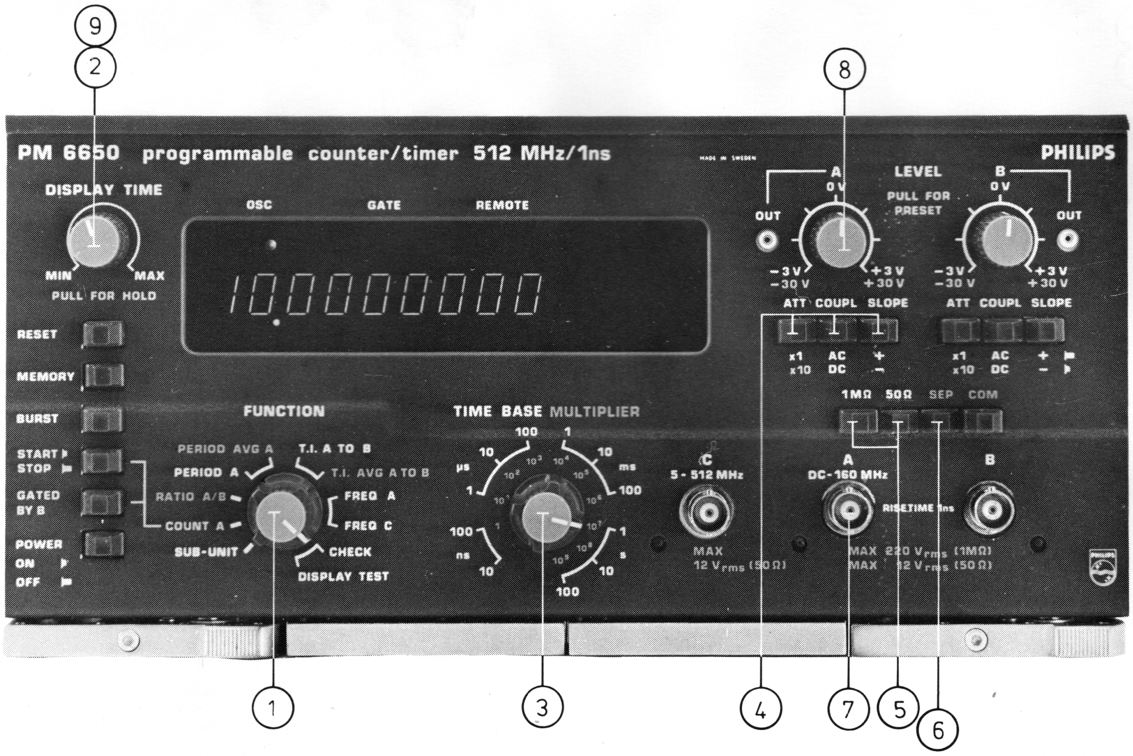
NOTE 2: Scaled output is available at rear panel output TIME BASE OUT. MULTIPLIER switch sets desired scaling factor. Frequency of input signal is max. 10 MHz.

2.7. Single period measurement



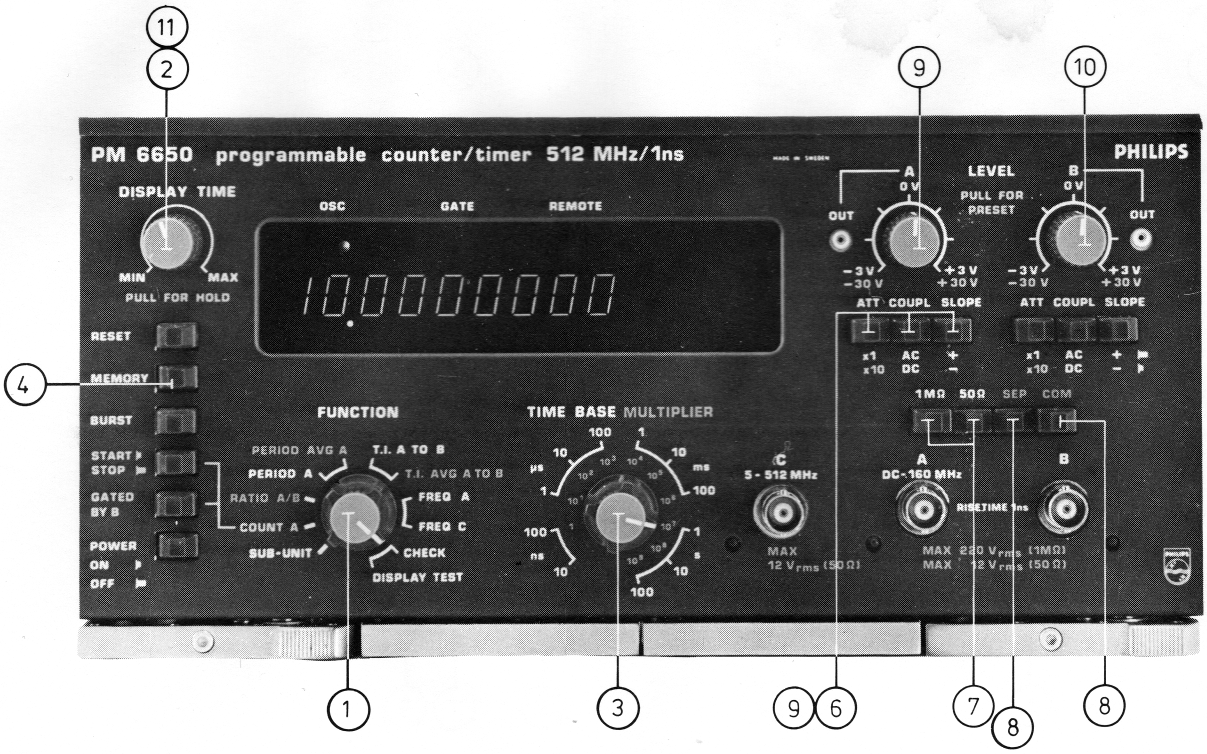
1. Set FUNCTION switch to PERIOD A.
2. Set DISPLAY TIME to mid-position.
3. Depress MEMORY switch.
4. Set TIME BASE/MULTIPLIER switch to desired time resolution (10 ns to 1 s).
5. Select desired input conditions of channel A (attenuation, coupling, slope).
6. Depress SEP switch.
7. Select suitable input impedance.
8. Connect signal to input A (frequency 0 to 10 MHz).
9. Adjust LEVEL A control to desired trigger level or pull to PRESET to trigger at zero volts.
10. Adjust DISPLAY TIME to desired position.

2.8. Period average measurement



1. Set FUNCTION switch to PERIOD AVG A.
2. Set DISPLAY TIME to mid-position.
3. Set MULTIPLIER switch to desired number of periods to be averaged.
4. Select desired input conditions of channel A (attenuation, coupling, slope).
5. Select suitable input impedance.
6. Depress SEP switch.
7. Connect signal to input A (O to 10 MHz).
8. Adjust LEVEL A control to desired trigger level or pull knob to PRESET to trigger at zero volts.
9. Adjust DISPLAY TIME to a suitable value.

2.9. Single time interval measurement



1. Set FUNCTION switch to T.I. A to B.
2. Set DISPLAY TIME to mid-position.
3. Set TIME BASE switch to desired resolution.
4. Depress MEMORY switch.
5. Select desired COUPLing and SLOPE of channel
5. Select desired COUPLing and SLOPE of channel A.
5. Select desired COUPLing and SLOPE of channel A.
6. Select desired COUPLing and SLOPE of channel B.
7. Select suitable input impedance.

8.a. Start/stop signals from common source:
Depress COM switch and connect signal to input A.

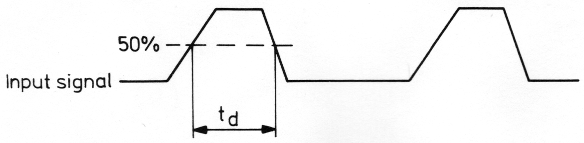
b. Start/stop signals from separate sources:
Depress SEP switch and connect start signal to input A and stop signal to input B.

9. Set ATTenuation A switch and LEVEL A control to desired start level. Monitor set level on oscilloscope connected to rear output LEVEL OUT A.
10. Set ATTenuation B switch and LEVEL B control to desired stop level.
Monitor set level on oscilloscope connected to rear output LEVEL OUT B.
11. Adjust DISPLAY TIME to desired position.

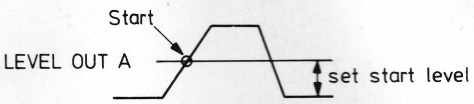
NOTE 1: Delay from STOP to the next START pulse must be at least 50 ns.

NOTE 2: Front panel miniature jacks LEVEL OUT can also be used to monitor set start or stop level.

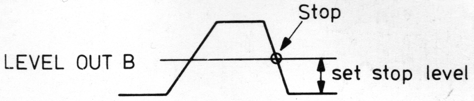
1. Measure pulse duration t_d



— Set SLOPE of channel A to "+".
— Set SLOPE of channel B to "—".
— Connect input signal to oscilloscope.
— Connect LEVEL OUT A to second channel of oscilloscope:

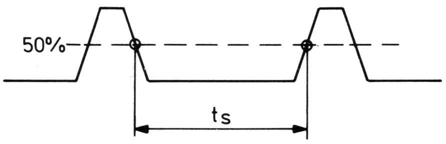


— Connect LEVEL OUT B to second channel of oscilloscope:

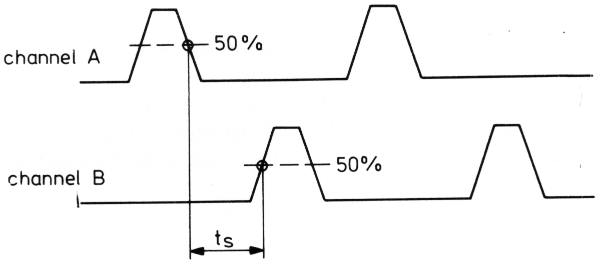


2. Measure pulse separation t_s

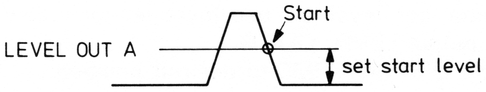
Start/stop signal from common source:



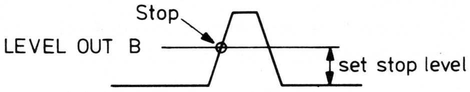
Start/stop signals från separate sources:



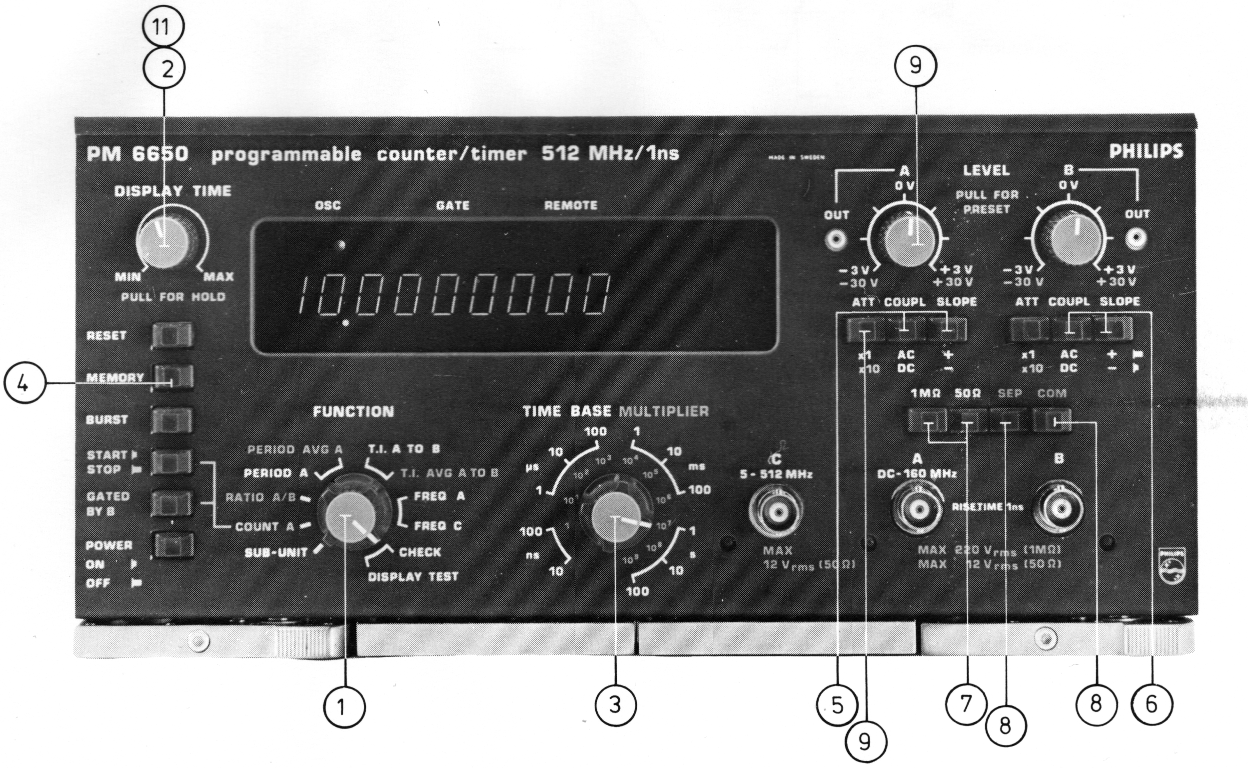
— Set SLOPE of channel A to "—".
— Connect input signal to oscilloscope.
— Set SLOPE of channel B to "+".
— Connect LEVEL OUT A to second channel of oscilloscope:



— Connect LEVEL OUT B to second channel of oscilloscope:



2.10. Time interval average measurement



1. Set FUNCTION switch to T.I. AVG. A to B.
2. Set DISPLAY TIME to mid-position.
3. Set MULTIPLIER switch to number of intervals to be averaged.
4. Depress MEMORY switch.
5. Select desired COUPLing and SLOPE of channel A.
6. Select desired COUPLing and SLOPE of channel B.
7. Select suitable input impedance.

8.a. Start/stop signals from common source:
Depress COM switch and connect signal to input A.

b. Start/stop signals from separate sources:
Depress SEP switch and connect start signal to input A and stop signal to input B.

9. Set ATTenuation A switch and LEVEL A control to desired start level. Monitor set level on oscilloscope connected to rear output LEVEL OUT A.
10. Set ATTenuation B switch and LEVEL B control to desired stop level.
    Monitor set level on oscilloscope connected to rear output LEVEL OUT B.
11. Adjust DISPLAY TIME to desired position.

NOTE 1: Delay from STOP to the next START pulse must be at least 50 ns.

NOTE 2: Start/Stop signal from common source has fast edges: greater accuracy is obtained if SEP switch is depressed and signal applied to inputs A and B via 50 Ω T-piece PM 9584.

NOTE 3: Avoid such conditions where the input signal is synchronous with the PM 6650's internal 10 MHz clock rate (e.g. if measuring object is phase-locked to the 10 MHz clock).